Technical Memorandum

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SUBJECT: **Far-Field Water Quality Analysis and Benefit Monetization in Support of the Water Storage Investment Program Application for the South Sacramento County Agriculture and Habitat Lands Recycled Water, Groundwater Storage, and Conjunctive Use Program (South County Ag Program) – Water Quality Priority 5 – Improve Salinity Conditions in Surface Water Bodies That Are Not Meeting Water Quality Standards**

Program Features

The South County Ag Program will provide a reliable source of tertiary recycled water to the southern portion of Sacramento County and impart the following benefits to the project area and downstream watershed:

- Maximize use of recycled water through delivery of this resource to agricultural uses in-lieu of groundwater pumping and for winter agricultural recharge.
- Reduce groundwater pumping in the Central Basin that will result in increased groundwater storage and increased streamflow in the Cosumnes River
- Enhance riparian habitat along the Cosumnes River with increased streamflows
- Provide a reliable water supply to managed wetlands
- Reduce the mass loading of salts to the lower Sacramento River and Delta by an average of approximately 190,000 lb/day (95 tons per day)

The South County Ag Program will act to improve the sustainability of groundwater resources in the southern portion of Sacramento County by providing high quality, Title 22 recycled water for irrigation, groundwater recharge, habitat and streamflow enhancement, while at the same time reducing the mass loading of salts to the Delta, which is included on the State's 303(d) list of impaired waters for electrical conductivity, a measure of salinity.

INTRODUCTION

The Sacramento Regional County Sanitation District (Regional San) owns and operates the Sacramento Regional Wastewater Treatment Plant (SRWTP) which is located at 8521 Laguna Station Road, Elk Grove, CA. The SRWTP provides wastewater treatment to the Sacramento area and surrounding cities, serving approximately 1.4 million residents. The SRWTP currently uses a secondary treatment process (high purity oxygen activated sludge) to treat domestic, commercial, and industrial waste streams generated in Regional San's service area. Disinfected secondary treated effluent is discharged via a diffuser located at the bottom of the Sacramento River near the town of Freeport. The SRWTP is currently authorized by its National Pollutant Discharge Elimination System (NPDES) permit (Order No. R5-2016-0020; NPDES No. CA0077682) to discharge up to 181 million gallons per day (mgd) average dry weather flow (ADWF) of disinfected treated effluent to the Sacramento River.

The current NPDES permit requires the District to upgrade the SRWTP to enable it to meet new effluent limitations included in the Order. The proposed treatment plant upgrade will result in the design and construction of a new advanced wastewater treatment plant called the EchoWater Project. The EchoWater Project facilities will produce disinfected, nitrified, denitrified and filtered effluent that will comply with the new, more stringent NPDES permit requirements. The proposed EchoWater Project facilities would produce improved effluent quality as compared to the quality of effluent produced by the SRWTP's existing secondary treatment processes. The new EchoWater Project facilities will retain a permitted discharge capacity of 181 mgd (ADWF). Details of the EchoWater Project are described in certified Draft and Final Environmental Impact Reports (EIRs) prepared by Regional San (SRCSD 2014a[1] and 2014b[2]).

Regional San is proposing the South County Ag Program (or Program), which would provide Title 22 disinfected tertiary treated recycled water produced by the EchoWater Project for irrigation, groundwater recharge, and habitat and streamflow enhancement in the southern portion of Sacramento County. The in-lieu recharge component of the proposed Program would deliver recycled water to agricultural uses in-lieu of groundwater pumping and for winter agricultural recharge. The extraction component of the proposed Program would provide groundwater for extraction during the driest 30 percent of years when banked water is available (RMC 2017).

The proposed Program would convey up to 50,000 acre-feet per year (AFY) of recycled water from the upgraded SRWTP (i.e., EchoWater Project) to up to 16,000 acres of irrigated lands in South Sacramento County and 400 acres of managed wetlands within the South Stone Lake area of the U.S. Fish & Wildlife Service Stone Lakes National Wildlife Refuge (Stone Lakes). The proposed Program would initially deliver up to about 32,500 AFY of recycled water for summertime irrigation, and, at full implementation of all project and program elements, would also provide an additional 17,000 AFY for groundwater recharge and winter irrigation, plus 500 AFY for Stone Lakes (SRCSD 2016). The 50,000 AFY of recycled water delivered to the

[1] https://www.regionalsan.com/sites/main/files/file-attachments/draft_eir_final.pdf

[2] https://www.regionalsan.com/sites/main/files/file-attachments/feir_southcountyag_2-10-2017002.pdf

Program at full implementation will result in a reduction of approximately 95 tons per day of salts (measured as total dissolved solids (TDS)) discharged to the lower Sacramento River and Delta. Details of the South County Ag Program are described in certified Draft and Final EIRs (https://www.regionalsan.com/post/south-county-ag-final-environmental-impact-report) (SRCSD 2016 and 2017).

This Technical Memorandum provides estimates of far-field ambient water quality for electrical conductivity (EC) in the Sacramento River and Sacramento-San Joaquin Delta (Delta) downstream of the SRWTP discharge under existing conditions ("Without Program") and "With Program" conditions for future 2030 and 2070 climate and sea-level conditions established for the Water Storage Investment Program (WSIP). Incremental changes in ambient water quality associated with the proposed Program are provided, as well as the mass loading reduction in salts. Additionally, this Technical Memorandum provides a monetization of the water quality benefits of the proposed Program through the determination of an alternative cost, reverse osmosis (RO) treatment of SRWTP effluent, to achieve the equivalent water quality benefit. The alternative cost method of monetizing water quality benefits is used because RO treatment represents a project that could happen as a means to provide the same water quality improvement as the proposed Program. RO treatment of SRWTP effluent is not a planned future project and therefore, its cost is not an avoided cost because it does not represent a reduction in a "without project" future condition. Willingness-to-pay is not considered as a viable cost approach because the entire cost of RO treatment is considered under the alternative cost approach. Additionally, data do not exist to determine California's willingness-to-pay for salinity removal in the Delta. Finally, this Technical Memorandum is intended to be a citable document to be used in the development of Regional San's application for Proposition 1 funding of the proposed Program by the California Water Commission through the WSIP.

BACKGROUND

The following information is provided, where relevant, to assist Regional San in answering Questions 1 – 9 included in the WSIP application table labeled "WSIP Data and Information Summary Table: General Application Questions for Water Quality Priorities".

1. Current Condition

The current condition date for the proposed Program is 2015. Climate change conditions were considered in the SacIWRM and CalSim II/Temperature Modeling Technical Memos as required in the Qualification Regulations and Technical Reference document (CWC 2016a and 2016b). Modeling technical memoranda are referenced in the answer provided to Question #9 on the Summary Table: General Application Questions for Water Quality Priorities.

2. Project Area

The proposed Program is located within Southern Sacramento County, and includes portions of unincorporated Sacramento County, and portions of the Stone Lakes National Wildlife Refuge. The Program area boundaries are Interstate 5 to the west, Highway 99 to the East, Bilby Road to the North, and Twin Cities Road to the South. The proposed recycled water service area is shown in Figure 1, "Project Location" that is included on page 3 of "Describing the Project: November 2016 Technical Reference section 3.3" GRANTS Grant Eligibility and General Project Information Tab, A.3 Project Description. With respect to water quality improvements related to salinity, the area impacted by the proposed Program is shown in **Figure 1** of this Technical Memorandum.

3. Area Affected by Changes to Surface Water Quality

The proposed Program will reduce future effluent discharge to the lower Sacramento River near the town of Freeport and deliver recycled water to lands in the southern portion of Sacramento County. A decrease in the discharge rate from the SRWTP will slightly improve water quality in the lower Sacramento River downstream of the discharge and into the Delta. The present analysis is focused on far-field water quality which is defined as the water quality that occurs at distances well downstream of the SRWTP discharge and where effluent and receiving water are well mixed. Based on prior far-field modeling work performed for Regional San in 2009 (SRCSD 2009) and 2014 (LWA 2014), the following six locations are evaluated in the current far-field assessment: Sacramento River at Greene's Landing/Hood, Sacramento River at Emmaton, Contra Costa Water District Pumping Plant # 1 at Rock Slough, Contra Costa Water District Los Vaqueros Intake at Old River, Delta Pumping Plant at Clifton Court Forebay, and Delta-Mendota Canal Headworks (see **Figure 1**). These "water quality impacts assessment locations" were selected due to either their proximity to a drinking water intake, agricultural water supply intake, Delta water quality compliance point, or a location of general water quality interest in the Delta. These six locations are the focus of the current water quality analysis because they possess sufficient ambient water quality data to be evaluated in a far-field assessment of the proposed Program at full implementation (i.e., 50,000 AFY recycled water deliveries to project area). Regional San's 2009 far-field modeling work also determined the percentage of SRWTP effluent reaching six other far-field Delta locations: South Fork Mokelumne River, Chipps Island, City of Stockton Delta Water Supply Intake, San Joaquin River at Stockton, Contra Costa Water District Alternative Intake, and Grant Line Canal (see **Figure 1**). Ambient water quality conditions at these locations were not evaluated due to lack of data (SRCSD 2009).

4. Existing and Potential Beneficial Uses

The Water Quality Control Plan for the Sacramento-San Joaquin River Basins (Basin Plan), originally adopted by the Central Valley Regional Water Quality Control Board (Central Valley Water Board) in 1975 and amended periodically, contains descriptions of the legal, technical, and programmatic bases for water quality regulation in the region. The Basin Plan describes the beneficial uses of major surface waters and the corresponding water quality objectives adopted to protect those beneficial uses. The 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan) also includes beneficial uses and corresponding water quality objectives applicable to the Delta. **Table 1** presents the existing beneficial uses for the Sacramento-San Joaquin Delta, the water body receiving the SRWTP discharge. Specifically, the SRWTP discharges disinfected tertiary treated effluent to the Sacramento River below Freeport Bridge, a location that falls within the legal boundary of the Delta. Potential and existing beneficial uses of the Cosumnes River are not listed in **Table 1** because the Larry Walker Associates (LWA) water quality analysis scope only extends to the Sacramento River discharge.

5. Potential Adverse Water Quality Impacts and Mitigation Measures

There are no known potential adverse water quality impacts for salinity associated with implementation of the proposed Program and therefore, there are no water quality mitigation measures required for implementation of the proposed Program. The diversion of treated effluent to the South County area will relocate salt from the 303(d) listed Delta to an area with low salinity surface and groundwater conditions. The recycled water will be applied at agronomic rates, thereby not impacting beneficial uses, nor adversely impacting the high-quality waters in the South County area. Salt and Nutrient Management Plans will be developed as needed in accordance with the Central Valley Salinity Alternatives for Long-Term Sustainability initiative (CV-SALTS).

Table 1. Beneficial Uses Designated for the Sacramento-San Joaquin Delta.

Beneficial Uses for Surface Water defined in the Basin Plan	Designated as Existing Beneficial Use for Sacramento-San Joaquin Delta[1]
Municipal and Domestic Supply (MUN)	Yes
Agricultural Supply: Irrigation (AGR)	Yes
Agricultural Supply: Stock Watering (AGR)	Yes
Industrial Process Supply (PROC)	Yes
Industrial Service Supply (IND)	Yes
Industrial Power Supply (POW)	*No*
Ground Water Recharge (GWR)	Yes[2]
Water Contact Recreation: Contact Recreation (REC 1)	Yes
Non-Contact Water Recreation (REC 2)	Yes
Shellfish Harvesting (SHELL)	Yes[2]
Commercial and Sport Fishing (COMM)	Yes
Warm Freshwater Habitat (WARM)	Yes
Cold Freshwater Habitat (COLD)	Yes
Migration of Aquatic Organisms: Warm Water (MIGR)	Yes
Migration of Aquatic Organisms: Cold Water (MIGR)	Yes
Fish Spawning, Warm Water (SPWN)	Yes
Fish Spawning, Cold Water (SPWN)	*No*
Wildlife Habitat (WILD)	Yes
Estuarine Habitat (EST)	Yes[2]
Rare, Threatened, or Endangered Species (RARE)	Yes[2]
Navigation (NAV)	Yes

1. Water Quality Control Plan for the Sacramento River Basin and San Joaquin River Basin, Fourth Edition, Revised July 2016 (CVRWQCB, 2016)
2. These existing beneficial uses are only designated for the Delta in the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan), December 2006 (SWRCB 2006).

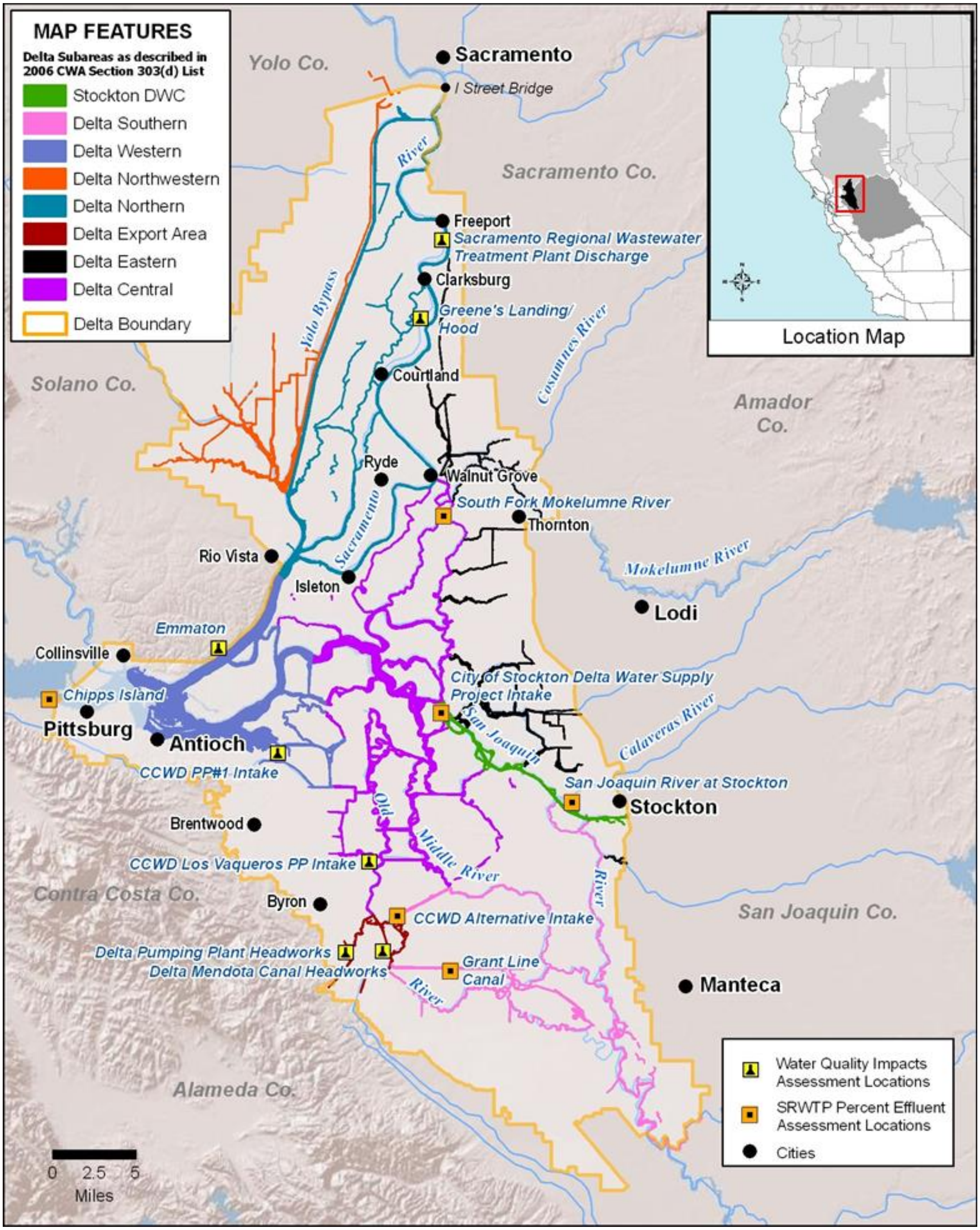

Figure 1: Far-field Delta Locations Considered to Assess Water Quality Impacts of the Proposed Program at Full Implementation (50,000 AFY).

6. Potential Impediments or Circumstances that May Reduce Project's Claimed Improvements

Implementation of the South County Ag Program (Program) requires that Regional San obtain approval of a Petition for Change for Owners of Waste Water Treatment Plants (Petition for Change) from the State Water Resources Control Board (SWRCB), Division of Water Rights pursuant to Section 1211 of the Water Code before making a change in the point of discharge, place of use, or purpose of use of treated water. The process for the Petition for Change is currently underway, and is anticipated to be completed by the end of 2017.

Approval of the Petition for Change would result in the issuance of an order from the SWRCB confirming Regional San's right to use the recycled water as set forth in the Petition, which would enable a change in the point of discharge from the Sacramento River to new places of use – farmlands, wetlands, and/or potential recharge areas, and would also enable a change in the purpose of use of the treated water. In reviewing and approving Petitions for Change, the Division of Water Rights (Division) must be able to find that the proposed change would not injure other legal users of water, would not unreasonably affect fish and wildlife, and would not be contrary to the public interest. This petition process also allows other parties to protest the application and raise concerns regarding any injury to their legal uses of the water involved, or environmental or public interest concerns. The SWRCB would issue an order approving the petition if the change of the discharge did not result in injury to legal users of the water involved or result in an unreasonable affect on fish and wildlife.

Under the Program, Regional San would maintain its existing discharge location at the Sacramento River, and would continue to maintain an NPDES permit for river discharge, but the proposed Program would reduce the volume of recycled water discharged to the Sacramento River at certain times of the year, with the new point of discharge being agricultural and urban irrigation customers, and wetlands, in addition to ongoing river discharge. The South County Ag Program has significant benefits such as, recovering groundwater levels, restoring habitats, enhancing groundwater & surface water connectivity, improving water quality and ensuring water supply flexibility for Sacramento County and the Delta. The Program would add greater flexibility to the management of the local groundwater and surface water resources conjunctively and contributes to the improved management of water resources at the regional and state-wide level.

Although the Program would divert up to 50,000 AFY of Regional San's current discharge to agricultural lands in southern Sacramento County, the impacts to Delta outflow are minimal. To put these values into perspective 50,000 AFY is less than 0.8 percent of the Dry and Critically Dry year type (D1641 40-30-30) average Delta outflow and is less than 1.3 percent of the Dry and Critically Dry year type (D1641 40-30-30) average Delta export relative to the Without Program condition. As the Program is implemented and the groundwater and surface water connectivity increases, any impacts to Delta outflows become mitigated. Essentially, as groundwater conditions improve, increases in streamflows occur and sufficient water is banked to support extractions and associated surface water diversions are reduced. After ten years of operations the impact of the Program is reduced by more than 50 percent (from 50,000 AFY down to 24,980 AFY). After twenty years of operations the impact of the Program is reduced by more than 80 percent (down to 7,970 AFY) and through the remaining life of the Program the risk of impacts to Delta outflow and Delta exporters is reduced to negligible levels.

At this time, there are several protests pending to Regional San's wastewater change petition (WW-0092) for the Project, and Regional San is in the midst of protest resolution discussions with the protestants. Regional San is hopeful that it will be able to resolve the pending protests without the need for a hearing before the SWRCB. Regional San will be reporting back to the SWRCB staff by September 15, 2017 regarding the status of the protest resolution efforts.

7. Does the Project Improve Conditions in a Groundwater Basin Where Undesirable Results Caused by Extraction Have Occurred?

The Program area is located within the Sacramento Valley groundwater basin, South American subbasin. The South American subbasin is classified as a high priority basin by the California Department of Water Resources (DWR), which is primarily under the jurisdiction of the Groundwater Sustainability Agency Sacramento Central Groundwater Authority (SCGA). This area is mainly outside the areas currently served by municipal water suppliers, but encompasses a small portion of Sacramento County Water Agency's (SCWA's) Zone 40. Thus, the primary water supply in the proposed Program area is groundwater pumped from private wells. Some growers in this area also divert surface water from creeks, canals, and the Sacramento River for irrigation of crops. As described in the SCGA's Groundwater Management Plan (GMP), intensive use of groundwater over the past 60 years has resulted in a general lowering of groundwater elevations in this area. Over time, isolated groundwater depressions have grown and coalesced into a single cone of depression that is centered in the southwestern portion of the Central Basin (Water Forum and SCWA 2006).

The Cosumnes River runs along the southeastern edge of the proposed Program area. Monitoring and modeling studies have established a relationship between groundwater usage and Cosumnes River flows, leading to the conclusion that groundwater pumping is primarily responsible for the decline in river flows in the late summer and fall, which have contributed to the degradation of fishery, wildlife, recreational, and aesthetic resources of the lower Cosumnes River.

One of the primary objectives of the proposed Program is to reduce groundwater pumping in the South American subbasin, in the Program service area, and contribute to long-term basin sustainability by supplying recycled water to agricultural customers in-lieu of use of groundwater. Additionally, the import of recycled water to the proposed Program area for in-lieu and winter recharge would result in substantially higher groundwater levels and, eventually, increased Cosumnes River flows. This in-lieu and winter recharge also will provide benefits to riparian habitats along the Cosumnes River. The initial benefits from recharge are accrued primarily to groundwater in storage, while later benefits are accrued primarily to surface water flows in the Cosumnes River (RMC 2017). Further detail of the improvements of groundwater conditions in the Central Sacramento groundwater basin and surface water conditions in the Cosumnes River with implementation of the proposed Program are provided in the *Integrated Groundwater and Surface Water Modeling Results Technical Memorandum* (RMC 2017), see also GRANTS Benefit Calculation, Monetization, and Resiliency tab, A.1 Project Conditions.

8a. Is There an Adaptive Management and Monitoring Plan for the Project?

The proposed Program will develop a final adaptive management and monitoring plan as the proposed Program is implemented. However, the framework for an adaptive management and monitoring program is described below.

8b. Briefly Describe the Adaptive Management and Monitoring Program Framework for the Project

The proposed Program is anticipated to improve ambient water quality in the Delta downstream of the SRWTP discharge with respect to salinity (as measured by EC). Regional San will continue to perform water quality monitoring according to the requirements of its NPDES permit and continue to participate in the Central Valley Water Board's Delta Regional Monitoring Program (Delta RMP). As part of ongoing Program operations, monitoring would be conducted to quantify benefits to the groundwater basin and to document the assurances that Regional San is providing to stakeholders and funding agencies as the Program is implemented. Ecosystem and hydrologic monitoring would be performed in cooperation with The Nature Conservancy and other resource managers responsible for lands within the Program (GRANTS Benefit Calculation, Monetization, and Resiliency tab, A.2 Preliminary Operations Plan, pg. 30).

Ecological Health

As a means to measure the progress made toward achieving the groundwater, hydrologic, and habitat improvement goals of the proposed Program, a framework for an adaptive management and monitoring program has been developed. Adaptive management is a component of the proposed Program's Preliminary Operations Plan and the South Sacramento County Agriculture and Habitat Lands Recycled Water, Groundwater Storage, and Conjunctive Use Program-Conceptual Ecological Plan & Ecosystem Benefits. Program monitoring will include three main components: (1) an assessment of the land management practices (e.g., winter irrigation, crop residue management, etc.) that are in place to create habitat and support wildlife, (2) riparian and wetland vegetation surveys to evaluate site conditions and function, and (3) monitoring to assess biological response. Monitoring would take the form of (1) rapid qualitative monitoring at individual sites, (2) remote effectiveness monitoring of the Program area, and (3) quantitative confidence monitoring on a sample of sites.

Groundwater Basin Health

Groundwater basin health would be monitored through groundwater elevation measurements. A groundwater elevation monitoring network would be established to cover slightly beyond the Program footprint. Numerous agricultural wells exist in the basin, and the effort would seek to include wells monitored by SCGA for the California Statewide Groundwater Elevation Monitoring program. Emphasis would be placed on wells screened at typical agricultural and municipal well depths. Selected wells for monitoring would be spread across the Program area to allow for estimation of stored water and estimation of losses to surface water. Existing wells in the service area of the yet-to-be-finalized groundwater banking partner would be leveraged to the extent possible for banking operations monitoring. If appropriate where wells are not present, new dedicated monitoring wells would be installed. Water level measurements would initially occur monthly and be refined as data is evaluated.

Salt and Nutrient Monitoring

Monitoring of salt and nutrients would occur through regular monitoring of the Groundwater Basin Health monitoring wells. These wells would be monitored semi-annually for Total Dissolved Solids and Nitrate for the initial five years of project operations, then annually unless data suggests the need for continuing to monitor more frequently.

9. Climate Change Risk Factor(s) Considered in the Project Siting and Design

Climate change conditions were analyzed for the WSIP application using groundwater and surface water models, as prescribed by the regulations Section 6004(1)(2) and the Technical Reference document Chapter 4 (CWC 2016b). The following climate change risk factors were considered when modeling the potential impacts of the proposed Program: temperature changes, changing precipitation and runoff, and the hydrologic variability associated with drought (RMC SacIWRM Groundwater Modeling Technical Memo, pg. 2 and CH2M CalSim II/Temperature Modeling Technical Memo, pg. 13, GRANTS Benefit Calculation, Monetization, and Resiliency tab, A.1 Project Conditions). The groundwater improvements and surface water benefits from this project provide the resiliency from modeled climate change impacts to support and protect the existing private and public investments which have been made in the watershed. This in addition to the proposed Program benefits.

ESTIMATED IMPROVEMENTS IN SURFACE WATER QUALITY CONDITIONS

Background

The following information is provided to assist Regional San in populating information required in the WSIP application table labeled "WSIP Data and Information Summary Table: Water Quality Priorities 1-5 (Water Bodies Not Meeting Standards)". Far-field incremental changes in ambient water quality in the lower Sacramento River and Delta downstream of the SRWTP discharge are estimated for existing conditions (Without Program) and "With Program" conditions for salinity. Surface water quality improvements with implementation of the proposed Program are estimated through use of existing modeling information. Regional San's 2014 assessment of changes in ambient water quality downstream of the SRTWP discharge with implementation of the EchoWater Project (LWA 2014) are used as a basis for estimating South County Ag Program impacts under 2030 and 2070 climate and sea-level conditions established for the WSIP. The WSIP-provided hydrologic data and CalSim II model allowed for consideration of projected climate conditions anticipated for the years 2030 and 2070 (CWC 2016c). The CalSim II model is used to simulate hydrology of the Central Valley and the water operations of the Central Valley Project, State Water Project, and the Delta. Specifically, the percent of SRWTP effluent that resides at far-field locations was determined through Regional San's 2014 modeling of the EchoWater Project. The estimated changes in far-field ambient EC levels with implementation of the proposed Program are based on both SRWTP percent effluent in the far-field and CalSim II model output that consider 2030 and 2070 climate and sea-level conditions established for the WSIP. The methods used for estimating future far-field incremental changes in ambient water quality downstream of the SRWTP discharge are described in **Appendix A**.

The following section describes estimated improvements in surface water quality conditions for salinity in the lower Sacramento River and Delta downstream of the SRWTP discharge in the years 2030 and 2070. For this analysis, all far-field ambient water quality estimates assume that the SRWTP will discharge disinfected tertiary treated effluent to the lower Sacramento River at a rate of 141 mgd (ADWF) (SRCSD 2014a). The projected effluent quality of the EchoWater Project for EC that is assumed in the far-field water quality analysis is that shown in **Table 2**.

Table 2. Projected Effluent Quality of the EchoWater Project for Electrical Conductivity.

Constituent (Unit)	Mean Concentration	Source
Electrical Conductivity (µmhos/cm)	760	Brown and Caldwell 2015

Using available modeling results, it is possible to estimate the future percent effluent values at the far-field locations due to implementation of the proposed Program. The percent effluent values may be used for different discharge scenarios (see **Table 3**) and ambient water quality to calculate the future water quality at the far-field Delta locations. As noted above, the delivery of 44.6 mgd (equivalent to 50,000 AFY) of Title 22 disinfected, tertiary treated recycled water to the Program area will result in a reduction of approximately 95 tons per day of salts discharged to the lower Sacramento River and Delta.

Table 3. SRWTP Discharge and Program Delivery Scenarios under Future Without Project and With Project Conditions.

Scenario	SRWTP Discharge (mgd)	Program Recycled Water Delivery (mgd)
Without Project	141	0.0
With Project**: Average Annual Delivery** (50,000 acre-feet per year to Program)	96.4	44.6

Salinity

Electrical Conductivity

Overview

Electrical conductivity (EC) is a common water quality parameter measured to provide an indication of the salinity of water. The major ionic substances in water – calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and nitrate – allow it to conduct an electrical charge, which is measured as the EC of the water. As the concentrations of the various ionic substances increase, so does the EC (and the total dissolved solids (TDS)) of the water. High EC or salinity levels may adversely impact the beneficial uses identified for a particular water body. High salts can impact the use of water for potable, agricultural, industrial, and environmental uses.

A discussion of electrical conductivity must be prefaced by a discussion of the regulatory mechanisms established by the State Water Resources Control Board (SWRCB or State Water Board) to control salinity in the San Francisco Bay and Sacramento-San Joaquin Delta Estuary. In 1978, the SWRCB adopted the first Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan), and has subsequently amended that plan in 1991, 1995, and 2006. A four-phase update of the plan is currently being considered by the SWRCB and the first two phases are expected to be adopted in 2018. Phase I proposes amendments to the Bay-Delta Plan involving the Lower San Joaquin River flow objectives and southern Delta salinity objectives. Phase II proposes amendments related to Delta outflow, Sacramento River and Delta tributary inflow, coldwater habitat and interior Delta flows. In Phase III, the State Water Board will implement changes to the Bay-Delta Plan from Phases I and II through water right actions. Phase IV will focus on the development and implementation of flows in the Sacramento River watershed to address tributary-specific public trust needs, with consideration of other beneficial uses of water, and will be integrated with the Phase II effort. The Bay-Delta Plan was developed as a means to mitigate the effects on Bay-Delta Estuary beneficial uses caused by water diversions and the use of water within the system (SWRCB 2006). Water quality objectives and flow requirements are included in the 2006 Bay-Delta Plan to protect beneficial uses by control of salinity sources (associated with saltwater intrusion, municipal discharges, and agricultural drainage) and by management of water project operations (flow and diversions).

Section 303(d) of the Clean Water Act requires states to develop lists of water bodies (or segments of water bodies) that will not attain water quality standards ("water quality objectives", in California) after implementation of minimum required levels of treatment by point-source dischargers (i.e., municipalities and industries). Section 303(d) requires states to develop a Total Maximum Daily Load (TMDL) for each of the listed pollutant and water body combinations for which there is "impairment". A TMDL is the amount of loading of a given constituent that the water body can receive and still meet water quality standards for that constituent. The TMDL must include an allocation of allowable loadings for both point and non-point sources, with consideration of background loadings and a margin of safety. NPDES permit limitations for listed pollutants must be consistent with allocations identified in adopted TMDLs. The most recent Clean Water Act Section 305(b) and 303(d) Integrated Report for the Central Valley Region (Final 2014 Integrated Report) includes listings of impairment for EC in four of the eight Delta Waterways: Export Area, Northwestern Portion, Southern Portion, and Western Portion. A TMDL for EC is required in these four Delta Waterways with an expected completion date of 2027 for all water bodies except for the Export Area, which has an expected completion date of 2019.

The Bay-Delta Plan includes water quality objectives to protect applicable beneficial uses designated for the Bay-Delta Estuary. Water quality objectives are included in the plan to protect agricultural, municipal, industrial service supply, and industrial process supply beneficial uses from the effects of salinity. These agricultural, municipal and industrial objectives also act to provide protection for water contact recreation, non-water contract recreation, designated fish and wildlife beneficial uses and groundwater recharge beneficial uses. The plan includes a host of compliance points in the Delta where chloride, electrical conductivity, dissolved oxygen, and flow objectives must be met, during certain times of the year, in order to protect designated beneficial uses. The Bay-Delta Plan and the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) are used to regulate salinity levels in the receiving waters (Sacramento River and Delta) that would be improved by the proposed Program by reducing the salt load to the lower Sacramento River by an average of approximately 95 tons per day.

Applicable Objectives/Criteria

The most stringent water quality objective for EC in the Sacramento River at Freeport is the California Code of Regulations Title 22 Secondary MCL, which ranges from 900 to 1,600 µmhos/cm, and is incorporated into the Basin Plan by reference. The Secondary MCL exists to support consumer acceptance of finished drinking water. The Sacramento River at Emmaton has its own seasonal EC objectives included in the 2006 Bay-Delta Plan based on water year type, as shown in **Table 4**. The southern Delta is also subject to seasonal, site-specific salinity objectives. In 1978, the State Water Resources Control Board (State Water Board) established the current southern Delta salinity/electrical conductivity objectives for the protection of agricultural beneficial uses in the 1978 *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary* (1978 Bay-Delta Plan). The 1978 Bay-Delta Plan included salinity objectives for the protection of agriculture in the southern Delta at four compliance locations including: the San Joaquin River (SJR) at Vernalis, the SJR at Brandt Bridge, Old River near Middle River, and Old River at Tracy Road Bridge. The approach used in developing the objectives involved an initial determination of the water quality needs of significant crops grown in the area, the predominant soil type, and local irrigation practices. The State Water Board based the southern Delta EC objectives on the calculated maximum salinity of applied water that sustains 100 percent yield of seasonally grown salt-sensitive crops. A summer irrigation season (April 1 – August 31) objective of 700 µmhos/cm was based on the salt sensitivity and growing season of beans and a winter irrigation season (September 1 – March 31) objective of 1000 µmhos/cm was based on the salt sensitivity and growing season of alfalfa during the seedling stage.

Table 4: Seasonal- and Water Year Type-Based Electrical Conductivity Objectives for the Sacramento River at Emmaton.

	Time Period	Maximum 14-day Running Average of Mean Daily EC (µmhos/cm)
Water Year Type	***450 µmhos/cm EC April 1 to Date Shown***	***EC from Date Shown to August 15***
Wet	Aug 15	---
Above Normal	Jul 1	630
Below Normal	Jun 20	1140
Dry	Jun 15	1670
Critical	---	2780

Information in above table taken from Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan), December 13, 2006.

Far-Field Assessment

The current SRTWP discharge contributes salts, as measured by EC, to the Sacramento River and Delta, as will the upgraded EchoWater Project facility. **Table 5** presents current and predicted 2030 and 2070 median ambient EC levels at select far-field locations downstream of the SRWTP discharge. The median concentration is appropriate for assessing the long-term protection of beneficial uses that are affected by salinity. The reason the far-field EC levels are very similar when comparing Without Program to With Program estimates, and appear less than expected based on the calculated salt load reduction in the SRWTP discharge, is due to the large volume of water in the Sacramento River and Delta compared to the volume of Regional San's discharge. However, the mass loading of salts to the lower Sacramento River and Delta would be reduced by an average of approximately 190,000 lb/day (95 tons per day) at full implementation of the proposed Program.

Table 5. Current and Predicted Median Electrical Conductivity Levels at Select Far-Field Locations Downstream of the SRWTP Discharge.

Far-Field Location	Median Electrical Conductivity (µmhos/cm)				
	Current Measured(1)	Predicted 2030 Without Program(2)	Predicted 2030 With Program(3)	Predicted 2070 Without Program(2)	Predicted 2070 With Program(3)
Greene's Landing/Hood	159	159	156	159	156
Emmaton	389	389	387	389	388
Rock Slough	428	428	427	428	427
Old River	356	356	355	356	355
Clifton Court Forebay	340	340	339	340	339
DMC Headworks	404	404	403	404	403

1. Ambient conditions reflective of SRTWP secondary treatment at a discharge rate of 141 mgd and median effluent electrical conductivity of 782 µmhos/cm.
2. Modeled ambient conditions reflective of EchoWater Project at a discharge rate of 141 mgd and median effluent electrical conductivity of 760 µmhos/cm.
3. Modeled ambient conditions reflective of average annual recycled water deliveries to proposed Program, an EchoWater Project discharge rate of 96.4 mgd, and median effluent electrical conductivity of 760 µmhos/cm.

MONETIZATION OF WATER QUALITY BENEFITS

Alternative Cost Approach

As described above, the delivery of 50,000 AFY of Title 22 disinfected tertiary treated recycled water to the southern portion of Sacramento County for irrigation, groundwater recharge, and habitat enhancement will result in an improvement in water quality for salinity in the lower Sacramento River and Delta downstream of the SRWTP discharge. The delivery of 50,000 AFY of Title 22 disinfected tertiary treated recycled water to the Program area will reduce the mass of salts discharged to the lower Sacramento River. An alternative to achieving an equivalent reduction in mass loading of salts to the river would be accomplished by treating a portion of the SRTWP effluent with a reverse osmosis (RO) membrane treatment process. RO treatment of SRWTP effluent would remove salts to a very low concentration (25 mg/L), and provide additional removal of the low levels of other constituents contained in the tertiary treated effluent as it is passed through RO membranes under high pressure. RO is an effective, albeit expensive, process used to remove dissolved and suspended species from water, and is commonly employed to remove salts and other constituents from effluent and drinking water. The removal of salts from SRWTP effluent via RO treatment would provide the same physical benefit as delivery of flows to the Program area. The RO treatment process would also result in the production of high quality RO product water that could be sold as a water supply.

The monetization of the benefits of reduced mass loading to the lower Sacramento River and Delta downstream of the SRWTP discharge can be accomplished by first calculating the cost of RO treatment to remove an equivalent mass of salt (Total Dissolved Solids or TDS) as contained in the 50,000 AFY of recycled water delivered under the proposed Program. Because RO treatment of SRWTP effluent is not planned by Regional San nor required under its current NPDES permit – the EchoWater Project will produce high quality effluent capable of meeting all requirements in the current NPDES Order – the cost of RO treatment is not considered an "avoided cost" under this benefit monetization exercise. Instead, the cost of RO treatment is viewed as an "alternative cost" because it offers a reliable, least-cost means of providing the same amount of physical benefit as the proposed Program, and is the only treatment process that can remove salts. Secondly, the value of the sale of RO product water is calculated and then subtracted from the RO treatment cost to provide a "net" alternative cost for the reduction of mass loading of salts to the lower Sacramento River and Delta.

The following RO treatment cost estimate is based on the operation of a virtual RO treatment facility that operates 365 days per year and treats 46.9 mgd of SRWTP effluent. A volume of effluent greater than 44.6 mgd (equivalent to 50,000 AFY) needs to be treated because the RO process doesn't remove all salt from the treated effluent. The RO treated effluent would contain TDS at a concentration of 25 mg/L. It is assumed that 80 percent of the volume of effluent that passes through RO membranes under high pressure would be available for sale as a high quality water supply. The RO treatment facility sizing assumptions made for estimating the cost of RO treatment are provided in **Table 6**.

Table 6: Assumptions Made for Operation of 44.6 mgd Virtual Reverse Osmosis Facility.

Annual Diversion	50,000 ac-ft
Average Daily Diversion	137.0 ac-ft
	44.6 mgd
TDS concentration in effluent	510 mg/L[(1)]
lb TDS/day in diversion	189,791 lb/day (approximately 95 tons per day)
TDS in effluent after RO treatment	25 mg/L (approximately equivalent to 95% salt rejection)
TDS reduction with RO treatment	485 mg/L
Flow requiring RO treatment	46.9 mgd
Average Daily Production Rate of RO Product Water	37.5 mgd
	115.2 ac-ft
Annual RO Product Water Production	42,000 ac-ft

1. SRCSD 2016

Planning level estimates of the capital and operations and maintenance (O&M) costs (in 2015 dollars) associated with implementation of RO treatment to remove an equivalent mass of TDS from SRWTP effluent as is achieved with the recycled water deliveries under the proposed Program are provided in **Table 7**. Because Regional San's existing facility in Elk Grove could accommodate the construction of a RO facility, the costs below do not include the cost of purchase of additional land for such a facility. The estimated annual revenue from the sale of RO product water is provided in **Table 8**, and the net alternative cost for the reduction of mass loading of salts to the lower Sacramento River and Delta is shown in **Table 9**.

Table 7: Planning Level Cost Estimate in 2015 Dollars for Reverse Osmosis (RO) Treatment of SRWTP Effluent to Remove an Equivalent Mass of Total Dissolved Solids (TDS) as Achieved by the Proposed Program.

RO Treatment (mgd) Required to Remove an Equivalent Mass as Proposed Program	Cost ($ Million)			
	Capital[1,2]	Annualized Capital[3]	Annual O&M[1]	Total Annual[1,2,4]
46.9	$284.5	$10.5	$28.1	$38.6

1. Capital and O&M costs developed using: Memorandum of Flow Basis for Treatment Train Costs as Previously Presented in “Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant” (Carollo, March 2009). (Carollo 2010).
2. Treatment costs include engineering, administrative, legal, and contingency. All costs in June 2015 dollars (ENRCCI 10597). The ENRCCI for the Central Valley (10597) was estimated by calculating the average of the U.S. 20-City Average (ENRCCI 10039) and the ENRCCI for San Francisco, CA (ENRCCI 11155), as of June 2015.
3. Annualized capital costs developed using an 84-year amortization period and 3.5 percent interest rate.
4. Total Annual Cost = Annualized Capital Cost + Annual O&M Cost.

Table 8: Estimated Annual Revenue from the Sale of Reverse Osmosis (RO) Product Water.

Avg. Daily RO Product Water Production (ac-ft)	Annual RO Product Water Production (AFY)	Water Supply Sale Price (ac-ft)[1]	Annual Revenue from Water Supply Sales
115.2	42,000	$400	$16,800,000

1. Assumes $400/ac-ft sale price for recycled water; value taken from Sacramento County Water Agency Recycled Water Feasibility Study, January 2017, Second Draft (SCWA 2017).

Table 9: Estimated Net Total Annual Cost in 2015 Dollars for Reverse Osmosis (RO) Treatment of SRWTP Effluent to Remove an Equivalent Mass of Total Dissolved Solids (TDS) as Achieved by the Proposed Program.

Cost ($ Million)			
RO Treatment Total Annual Cost	Water Supply Sales Annual Revenue	RO Treatment Net Total Annual Cost	Present Value
$38.6	($16.8)	$21.8	$588

1. Present value represents the summation of the capital construction cost plus the capitalized annual O&M cost for RO Treatment (see **Table 7**) based on an 84-year planning period and 3.5 percent interest rate.

In addition to the production of RO product water, the RO treatment process would produce a concentrated brine that would require disposal. Brine disposal alternatives include crystallization and land disposal, evaporation/containment ponds, piping or trucking liquid brine for off-site disposal, or deep-well injection. For communities such as Sacramento, which is located a significant distance from the ocean or other suitable disposal sites, liquid brine transport is not cost-effective. The volumes of brine generated at the community level are also problematic for deep-well injection. The most viable alternatives are crystallization and disposal (a high energy process) and use of evaporation/containment ponds (a land-intensive option), each of which represent costly options with an irretrievable commitment of resources. The RO treatment costs provided in **Table 7**, above, include the cost of thermal brine concentration, crystallization, and land disposal.

Other Cost Approaches Considered in this Analysis

The California Water Commission's November 2016 Technical Reference document used to support this WSIP application process describes the monetization of water quality benefits based on three cost approaches: avoided cost, alternative cost, and willingness-to-pay. The Technical Reference also states that physical benefits must be monetized using one or more of these three approaches (CWC 2016b; see page 5-3). As described above, the monetization of water quality benefits for the proposed Program uses an alternative cost approach to estimate the cost of RO treatment that would provide an equivalent physical benefit, in terms of salt load reduction to downstream receiving waters, as the proposed Program. An avoided cost approach was not used in this analysis because an avoided cost approach is only appropriate for monetizing the benefit of a project that is anticipated to occur. Again, RO treatment of SRWTP effluent is not a planned future project and its cost would not be incurred if the proposed Program was not implemented, nor would its costs be reduced if the proposed Program is implemented.

As described in the Technical Reference document, willingness-to-pay benefits are the maximum amount Californians are willing to pay to obtain the project's net physical benefit if no alternatives are available (CWC 2016b; see Step 3: Estimate Willingness-to-Pay Values on page 5-14). The current analysis has identified an alternative to the physical benefit of the proposed Program, and that is the removal of an equivalent mass of salt from SRTWP effluent via RO treatment as is contained in recycled water that would be delivered to the Program area. Because the entirety of the physical benefit monetization for the proposed Program is considered under the alternative cost approach used in this analysis, there is no willingness-to-pay cost that needs to be included in the monetized benefit[3] of the proposed Program.

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[3] The monetized benefit of the proposed project shall be calculated as the avoided cost (if any) plus, for any portion of the physical benefit not monetized as an avoided cost, the minimum of the feasible alternative cost value (if any) and the willingness-to-pay value (if any). Taken from page 5-11 of the Technical Reference document (CWC 2016b).

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Appendix A: 2030 and 2070 Water Quality Estimates

Surface water quality improvements resulting from implementation of the proposed Project have been estimated through use of existing modeling information derived from studies performed by Regional San in 2009 and 2014 (SRCSD 2009; LWA 2014). Regional San's 2014 assessment of changes in ambient water quality downstream of the SRTWP discharge associated with implementation of the EchoWater Project (LWA 2014) is used in this analysis as the primary basis for estimating future impacts for the Water Storage Investment Program (WSIP).

A key component of the water quality analysis is the determination of "percent effluent" at downstream locations. The percent effluent is defined as the volume of effluent contained in a sample volume of ambient water.[4] The 2014 ambient water quality analysis provides modeled estimates of the daily average percentage of SRWTP effluent at the far-field water quality impacts assessment locations presented in **Figure 1** (LWA 2014). The 2014 impact scenarios considered average SRWTP discharge rates of 141 mgd and 181 mgd. The modeled, median daily average percent SRWTP effluent values at 2014 far-field water quality impacts assessment locations and at the 2009 SRWTP percent effluent assessment locations are presented in **Table A-1** (SRCSD 2009; LWA 2014). Although not directly used in the water quality impacts assessment, the 2009 percent effluent values are useful in illustrating the spatial extent to which SRWTP effluent travels in the Delta. Slight decreases in ambient EC levels are expected at these locations with implementation of the proposed Program. A brief description of how modeled, median daily average percent SRWTP effluent values in the far-field were calculated is provided in **Appendix B**.

To determine water quality impacts associated with the proposed Program under the WSIP, adjustments to the 2014 water quality assessment were needed to adjust for the differing Delta conditions that will exist in 2030 and 2070. Net Delta outflow and total export values for 2015 (existing condition), 2030 and 2070 were used as the basis for these adjustments. Net Delta outflow and total exports together are a measure of the water passing through the Delta, with the former being an accounting of the water flowing to San Francisco Bay and the latter the amount diverted from the Delta for agricultural and drinking water uses. Both net Delta outflow and total exports are outputs from California Department of Water Resources generalized water resources simulation model (CalSim II) model runs.

[4] Percent effluent = (volume of effluent)/(volume of ambient water + volume of effluent).

Table A-1. Modeled Median Daily Average Percent SRWTP Effluent at Far-Field Water Quality Locations at Two Discharge Rates.

		Median Percent Effluent	
Far-Field Location	**Delta Waterway**	**141 mgd**	**181 mgd**
Water Quality Impacts Assessment Locations			
Sacramento River at Greene's Landing/Hood(1)	Northern Portion	1.45	1.81
Sacramento River at Emmaton(1)	Western Portion	1.27	1.59
CCWD PP #1 Intake at Rock Slough(1)	Western Portion	1.09	1.37
CCWD Los Vaqueros Intake at Old River(1)	Central Portion	1.03	1.30
Clifton Court Forebay	Export Area	0.90	1.13
Delta-Mendota Canal Headworks(1)	Export Area	0.60	0.75
SRWTP Percent Effluent Assessment Locations			
South Fork Mokelumne River(2)	Central Portion	---	0.69
Chipps Island(2)	*Outside of Delta*	---	1.10
City of Stockton Delta Water Supply Intake(1)	Stockton Deep Water Ship Channel	0.00	0.00
San Joaquin River at Stockton(2)	Stockton Deep Water Ship Channel	---	0.01
CCWD Alternative Intake(2)	Southern Portion	---	1.14
Grant Line Canal(2)	Southern Portion	---	0.00

1. Percent effluent results from LWA 2014.
2. Percent effluent results from SRCSD 2009.

The sum of net Delta outflow[5] and total exports[6] under existing and future conditions are presented in **Table A-2**, and are used as a measure of the available ambient water in which SRWTP effluent would be diluted. Using the modeled percent SRWTP effluent at far-field locations, a SRWTP discharge rate of 141 mgd, and the estimated Delta water available to dilute SRWTP effluent, the future percent effluent at the far-field locations has been estimated due to implementation of the proposed Program. The percent effluent values have then been combined with the discharge rate and ambient water quality to calculate the future water quality at the far-field locations.

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[5] An estimate of net Delta outflow at Chipps Island is derived by performing a water balance about the boundary of the Sacramento-San Joaquin Delta, taking Chipps Island as the western limit. The outflow is defined as the total flow into the delta plus precipitation, minus channel depletion, exports, and flooded island diversions.

[6] The total exports parameter accounts for all water diverted from the Delta by the Federal and State projects and others to meet water agreements and contracts. These include Central Valley Project pumping at Tracy, the Contra Costa Water District Diversions at Middle River, Rock Slough, and Old River, the North Bay Aqueduct export, and State Water Project exports (Banks Pumping Plant or Clifton Court Intake).

Table A-2. Estimated Net Delta Outflow and Total Exports for Considered Timeframes.

	Median Monthly Average Flow[1] (cfs)				
Value	**2015 Without Program**	**2030 With Program**	**2030 Without Program**	**2070 With Program**	**2070 Without Program**
New Delta Outflow	10,425	10,304	10,360	10,938	10,938
Exports	6,886	6,578	6,590	5,682	5,708
Total	17,310	16,882	16,949	16,620	16,645

1 As calculated by CalSim II using hydrologic conditions reflective of the indicated year.

Future flow scenarios include: Without Program, where all SRWTP effluent is discharged to the Sacramento River; and With Program, where a portion of the SRWTP effluent is delivered to the South County Ag Program project area. It is planned that between 1,000 acre-feet and 6,400 acre-feet per month will be delivered to the Program area based on variable water demand throughout the agricultural growing cycle. Future SRWTP discharge and Program delivery scenarios are presented in **Table A-3**. Because the virtual RO treatment facility discussed in the Monetization of Water Quality Benefits section of this Technical Memorandum would not need to be operated to meet any type of seasonal demand for salt removal from SRWTP effluent, the operation of such a facility was assumed to occur year around to remove an equivalent mass of salt on an annual basis as the proposed Program's delivery of 50,000 AFY to the Program area.

Table A-3. SRWTP Discharge and Program Delivery Scenarios.

Scenario	**SRWTP Discharge (mgd)**	**Program Recycled Water Delivery (mgd)**
Without Program	141	0.0
With Program: **Minimum Monthly Delivery** (1,000 acre-feet per month to Program)	130.1	10.9
With Program**: Average Annual Delivery** (50,000 acre-feet per year to Program)	96.4	44.6
With Program: **Maximum Monthly Delivery** (6,400 acre-feet per month to Program)	71.5	69.5

The future percent effluent at each of the far-field locations is estimated by applying the applicable ratio of the SRWTP discharge and available water in the Delta. The projected effluent percentages at the far-field locations for the Without Program scenario (under current, 2030, and 2070 conditions) with a SRWTP discharge rate of 141 mgd are listed in **Table A-4**. The projected effluent percentages at the far-field locations with implementation of the proposed Program (under 2030 and 2070 conditions) at a minimum recycled water delivery rate of 1,000 acre-feet per month and a SRWTP discharge rate of 130.1 mgd are listed in **Table A-5**. The projected effluent percentages at the far-field locations with implementation of the proposed Program (under 2030 and 2070 conditions) at an average recycled water delivery rate of 50,000 AFY and a SRWTP discharge rate of 96.4 mgd are listed in **Table A-6**. The projected effluent percentages at the far-field locations with implementation of the proposed Program (under 2030 and 2070 conditions) at a maximum recycled water delivery rate of 6,400 acre-feet per month and a SRWTP discharge rate of 71.5 mgd are listed in **Table A-7**.

Table A-4. Modeled Median Daily Average Percent Effluent for Current, 2030 and 2070 Without Program Conditions.

	Median Percent Effluent		
Far-Field Location	**Current**	**2030 Without Program**	**2070 Without Program**
Sacramento River at Greene's Landing/Hood	1.45	1.48	1.51
Sacramento River at Emmaton	1.27	1.30	1.32
CCWD PP #1 Intake at Rock Slough	1.09	1.11	1.13
CCWD Los Vaqueros Intake at Old River	1.03	1.05	1.07
Delta PP at Clifton Court Forebay	0.60	0.61	0.62
Delta-Mendota Canal Headworks	0.90	0.92	0.94

Table A-5. Modeled Median Daily Average Percent Effluent for 2030 and 2070 Program with Minimum Monthly Delivery of 1,000 acre-feet per month.

	Median Percent Effluent	
Far-Field Location	**2030 With Program**	**2070 With Program**
Sacramento River at Greene's Landing/Hood	1.39	1.41
Sacramento River at Emmaton	1.21	1.23
CCWD PP #1 Intake at Rock Slough	1.04	1.06
CCWD Los Vaqueros Intake at Old River	0.98	1.00
Delta PP at Clifton Court Forebay	0.86	0.87
Delta-Mendota Canal Headworks	0.57	0.58

Table A-6. Modeled Median Daily Average Percent Effluent for 2030 and 2070 Program with Annual Average Delivery of 50,000 AFY Deliveries.

	Median Percent Effluent	
Far-Field Location	**2030 With Program**	**2070 With Program**
Sacramento River at Greene's Landing/Hood	1.08	1.09
Sacramento River at Emmaton	0.94	0.95
CCWD PP #1 Intake at Rock Slough	0.80	0.81
CCWD Los Vaqueros Intake at Old River	0.75	0.76
Delta PP at Clifton Court Forebay	0.66	0.67
Delta-Mendota Canal Headworks	0.44	0.45

Table A-7. Modeled Median Daily Average Percent Effluent for 2030 and 2070 Program with Maximum Monthly Delivery of 6,400 acre-feet per month.

	Median Percent Effluent	
Far-Field Location	**2030 With Program**	**2070 With Program**
Sacramento River at Greene's Landing/Hood	0.85	0.86
Sacramento River at Emmaton	0.73	0.74
CCWD PP #1 Intake at Rock Slough	0.62	0.63
CCWD Los Vaqueros Intake at Old River	0.58	0.58
Delta PP at Clifton Court Forebay	0.51	0.52
Delta-Mendota Canal Headworks	0.35	0.35

Electrical Conductivity

The measured median far-field EC levels used in Regional San's 2014 ambient water quality assessment require adjustment to account for the fact that they reflect a secondary treated SRWTP discharge at 141 mgd (LWA 2014). Using the modeled median daily average percent SRWTP effluent values presented in **Table A-1** and the measured median ambient EC levels reflective of SRWTP secondary effluent presented in **Table A-8**, the secondary effluent contribution to EC levels at far-field locations is removed. The modeled contribution from the future EchoWater discharge (representing the same quality water as delivered to the proposed Program) is added back to the far-field locations at the appropriate no project effluent percentages reflective of the future hydrologic conditions (i.e., 2030 and 2070) as presented in **Table A-4**. These far-field Without Program median EC levels are presented in **Table A-8**. Similarly, the modeled With Program median EC levels at the far-field locations representative of the various Program delivery rates are presented in **Table A-9**.

Table A-8. Far-Field Median Ambient Electrical Conductivity Levels (µmhos/cm) Without Program Implementation.

Far-Field Location	Measured Median EC[1] (µmhos/cm)	Estimated 2030 Without Program[2] (µmhos/cm)	Estimated 2070 Without Program[2] (µmhos/cm)
Sacramento River at Greene's Landing/Hood	159	158.87	159.03
Sacramento River at Emmaton	389	388.82	388.91
Rock Slough (CCWD Pumping Plant #1)	428	427.84	427.91
Old River (CCWD Los Vaqueros Intake)	356	355.86	355.94
Delta PP at Clifton Court Forebay	340	339.88	339.95
Delta-Mendota Canal Headworks	404	403.91	403.95

1 Ambient conditions reflective of SRWTP secondary treatment at a discharge rate of 141 mgd and mean effluent EC of 782 µmhos/cm.

2 Modeled ambient conditions reflective of the EchoWater Project discharging at 141 mgd and median effluent EC of 760 µmhos/cm (median effluent EC value taken from Brown and Caldwell 2015).

Table A-9. Far-Field Modeled Median Electrical Conductivity Levels (µmhos/cm) With Program Implementation.

	With Program Delivery Rate					
	Minimum Monthly		Average Annual		Maximum Monthly	
Far-Field Location	2030 Conditions	2070 Conditions	2030 Conditions	2070 Conditions	2030 Conditions	2070 Conditions
Greene's Landing/Hood	158.29	158.42	156.39	156.50	154.99	155.07
Emmaton	388.51	388.58	387.47	387.52	386.70	386.74
Rock Slough	427.59	427.65	426.78	426.82	426.18	426.21
Old River	355.57	355.64	354.62	354.67	353.92	353.95
Clifton Court Forebay	339.63	339.68	338.78	338.83	338.16	338.20
DMC Headworks	403.77	403.80	403.31	403.33	402.97	402.98

Appendix B: Delta Water Quality Modeling

A system of computer models was employed by Flow Science, Inc. to simulate transport and mixing conditions in the near-field and far-field to characterize the water quality impacts of Regional San's EchoWater Project. Empirical data characterizing typical water quality and flow rates of the SRWTP discharge were used in the modeling effort. The models used in support of the water quality analysis included: (1) California Department of Water Resources generalized water resources simulation model (CalSim II); (2) the Delta Simulation Model II (DSM2); (3) a near-field three-dimensional model (3-D), FLOWMOD; (4) a longitudinal dispersion model (LDM) for the Sacramento River; and (5) the U.S. EPA's Dynamic Toxicity Model (DYNTOX). The relationship between these models is illustrated in **Figure B-1**.

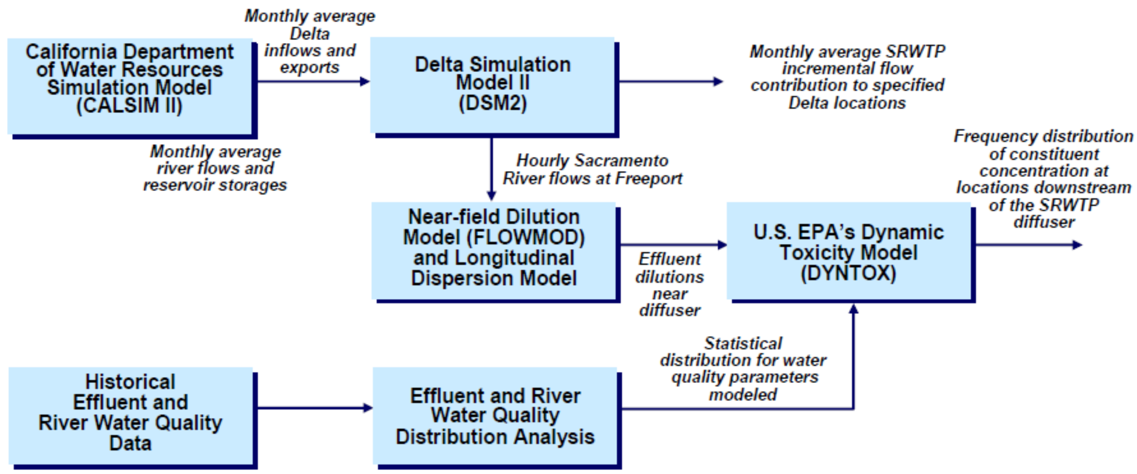

Figure B-1: Linkages between the Hydrologic and Water Quality Models.

With respect to the calculation of SRWTP percent effluent at far-field locations, CalSim II was used to define system-wide hydrology conditions. The model simulates an 82-year hydrologic period of records (water years 1922 – 2003, inclusive). Hourly flow rates in the Sacramento River at the SRWTP discharge location were calculated using the DSM2 model, which is currently the most widely used model for simulating flow and water quality in the Delta. DSM2 was also used to simulate the incremental concentration of water quality constituents, due to SRWTP discharge, at six selected far-field locations in the Delta. These estimates combined the DSM2 modeled SRWTP effluent concentrations at these locations and the constituent concentrations in the discharge (assuming that these constituents behave conservatively in the environment) (FSI 2013). For model input/ouput data see GRANTS Physical Public Benefits tab, A.2 Water Quality Supporting Documentation, files Regional San_DSM2 modeled SRWTP effluent percent_A.2 WQ Benefits Supporting Docs_SecPPB.zip, and Regional San_WQ Quantification Support_A.2 WQ Benefits Supporting Doc_SecPPB.zip.